Further, the above examples may be applied to a digital processing device.

According to the present invention, an error can be corrected before propagation of the error which occurs in decoding the run length limited code to the NRZ data by correcting the error on the run length limited code. The number of bits to be corrected can be therefore reduced and the redundant bits can be reduced.

Further, according to the present invention, the redundant bits of the error correcting code can be reduced in view of the correction capability and the run length limitation can be satisfied in a recording and reproducing device using the run length limited code and using a disk type record medium.

While we have shown and described several embodiments in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to those skilled in the art, and we therefore do not wish to be limited to the details shown and described herein but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

We claim:

1. Apparatus for at least recording user data to be recorded on a record medium, comprising:

record encoding means for converting original user data into encoded user data of a predetermined record code;

error correcting code generating means for generating original error correcting code data for correcting an error with respect to the encoded user data;

converting means for converting the error correcting code data into encoded correcting code data adapted to the predetermined record code[the recording means recording the encoded record data and the encoded correcting code data on the recording medium]

recording means including means for writing data including the encoded record data and encoded error correcting code data on the record medium; and

reproducing means including reading means for reading data from the record medium including the encoded user data and the encoded error correcting code data;

inverse converting means for inversely converting the encoded error correcting code data read by the reading means into the original error correcting code data;

error correcting means for correcting an error with respect to the encoded user data read by the reading means based on the original error correcting code data; and

decoding means for decoding the encoded user data having errors which have been corrected by the error correcting means to the original user data.

2. Apparatus according to claim 1, wherein the predetermined record code is a run length limited code for restricting a continuation of a predetermined first value in a series of the user code data, the converting means converting the error correcting code data into the encoded error correcting code data by inserting a value other than the predetermined value to the error correcting code data generated by the error correcting code generating means so that conversion is effected in accordance with the restriction of the run length limited code, and the inverse converting means inversely converts the encoded error correcting code data into the original error correcting code data by deleting the inserted value which has been inserted by the converting means from the encoded error correcting code data so as to effect conversion in accordance with the restriction of the run length limited code.

3. Apparatus according to claim 2, further comprising:

PRML (Partial Response Maximum Likelihood) processing means performing decoding by a PRML using a PR (Partial Response) Class 4;

pre-coding means for pre-coding the encoded user data and the encoded error correcting code data so that the encoded error correcting code data is adapted to the record code;

the writing means writing the encoded user data and the encoded error correcting code data on the recording medium after pre-coding by the pre-coding means;

the PRML processing means decoding each of the encoded user data and the encoded error correcting code data read by the reading means and encoded by the pre-coding means with respect to every dual series of an odd number series and an even number series;

the converting means rearranging the odd number series and the even number series of the error correcting code data which has been generated by the error correcting code generating means at every insertion of the value other than the predetermined value; and

the inverse converting means deleting the value which has been inserted by the converting means from the encoded error correcting code data which has been decoded by the PRML processing means and rearranging the odd number series and the even number series of the error correcting code data at every deletion of the inserted value other than the predetermined value.

4. Apparatus according to claim 1, wherein the error correcting code generating means additionally generates error correcting code data with respect to data at an identification portion when the encoded user data is divided into a plurality of sectors and recorded by adding the identification portion including recognition information to each of the plurality of sectors.

5. Apparatus according to claim 1, further comprising:

writing means for writing a synchronization pattern which is a pattern for previously determined data on the record medium;

synchronization detecting means for comparing the previously determined synchronization pattern with a pattern of data in a data series of the data read by the reading means in an order and determining a pattern of data which is in agreement with the data of the synchronization pattern by at least a predetermined bit number as the synchronization pattern; and

wherein the synchronization pattern is a pattern of data which is not in agreement with a pattern of arbitrary data other than the pattern of the data corresponding to the synchronization pattern included in the data series of the data written on the record medium by at least the predetermined bit number and the pattern of the arbitrary data includes the pattern of the data including the data forming the portion of the pattern of the data corresponding to the synchronization pattern.

6. Apparatus according to claim 1, wherein the error correcting means detects an occurrence of an error based on the encoded user data read by the reading means and the original error correcting code data which has been inversely converted by the inverse converting means to perform correction of the error when the error has been detected;

the decoding means decoding the encoded user data read by the reading means and converted by the record encoding means before correction by the error correcting means;

the apparatus further comprising:

storing means for temporarily storing the decoded user data decoded by the decoding means; and

control means for reading the user data stored by the storing means and corresponding to the encoded user data in which an error has been detected when the error is detected by the error correcting means, reconverting the read user data into reconverted encoded user data of the record code, and transmitting the reconverted encoded user data to the error correcting means for correcting the error;

the decoding means redecoding the reconverted encoded user data having the error corrected by the error correcting means to the original user data.

7. Apparatus according to claim 2, wherein the run length limited code is a (0, 4, 4) GCR (Group Coded Recording), and the converting means inserts 1 as the value other than the predetermined value.

8. A method of correcting an error in a recording and reproducing apparatus for recording user data to be recorded on a record medium, comprising the steps of:

converting original use data into an encoded user data of a predetermined record code;

generating an original error correcting code data for correcting an error with respect to the encoded user data;

converting the generated error correcting code data into an encoded error correcting code data adapted to the predetermined record code;

writing the encoded user data and the encoded error correcting code data on the record medium;

reading the encoded user data and the encoded error correcting code data from the record medium;

inversely converting the read encoded error correcting code data to the original error correcting code data;

correcting an error with respect to the read encoded user data based on the original error correcting code data; and

decoding the encoded user data having errors which have been corrected by error correction to the original user data.

* * * * *

9. A storage device for at least recording user data to be recorded on a recording medium, comprising:

a record encoder which converts original user data into encoded user data of a predetermined record code;

an error correcting code generator which generates original error correcting code for correcting an error with respect to the encoded user data;

a convertor which converts the error correcting code data into encoded correcting code data adapted to the predetermined record code;

a recorder including a writer which writes data including the encoded record data and encoded error correcting code data on the record medium;

a reproducer including a reader which reads data from the record medium including the encoded user data and the encoded error correcting code data;

an inverse convertor which inversely converts the encoded error correcting code data read by the reader into the original error correcting code data;

an error corrector which corrects an error with respect to the encoded user data read by the reading means based on the original error correcting code data; and

a decoder which decodes the encoded user data which have been corrected by the error corrector to the original user data.

10. A data storage device, for recording data on a record medium, comprising:

a recording medium;

a write head;

a read head;

an interface circuit;

a record encoding circuit which converts original data which is provided through said interface circuit, into encoded data of a predetermined record code;

an error correcting code generating circuit which generates original error correcting code data for correcting an error with respect to the encoded data;

a converting circuit which converts the original error correcting code data into encoded error correcting code data adapted to the predetermined record code;

a recording circuit which generates a signal with respect to the encoded data and the encoded error correcting code data which is provided to the write head;

a reproducing circuit which reproduces the encoded user data and the encoded error correcting code data from a signal read from said recording medium by said read head;

an inverse converting circuit which inversely converts the encoded error correcting code data reproduced by said reproducing circuit into the original error correcting code data;

an error correcting circuit which corrects an error with respect to the encoded data read by the reproducing circuit

based on the original error correcting code data; and

a decoding circuit which decodes the encoded data which have been corrected by the error correcting circuit to the original data.

11. A data storage device according to claim 10, wherein the predetermined record code is a run length limited code for restricting a continuation of a predetermined first value in a series of data, and said converting circuit converts the error correcting code data into the encoded error correcting code so that conversion is effected in accordance with the restriction of the run length limited code.

12. A data storage device according to claim 10, further comprising:

a PRML (Partial Response Maximum Likelihood) processing circuit which performs decoding by a PRML using a PR (Partial Response) class 4; and

a pre-coding circuit which pre-codes the encoded user data and the encoded error correcting code data so that the encoded error correcting code data is adapted to the record code.

13. A data storage device for recording data on a record medium, comprising:

a recording medium;

a write head;

a read head;

an interface circuit;

a record encoding circuit which converts original data, which is provided through said interface circuit, into encoded data of a predetermined record code;

an error correcting code generating circuit which generates original error correcting code data for correcting an error with respect to the encoded data;

a converting circuit which converts the original error correcting code data into encoded error correcting code data adapted to the predetermined record code;

a recording circuit which generates a signal with respect to the encoded data and the encoded error correcting code data, and provides the signal to said write head;

a reproducing circuit which reproduces the encoded data and the encoded error correcting code data from a signal read from said recording medium by said read head;

an inverse converting circuit which inversely converts the encoded error correcting data reproduced by said reproducing circuit into the original error correcting code data;

an error checking circuit which checks the encoded data reproduced by said reproducing circuit utilizing the original error correcting code data obtained by said inverse converting circuit whether or not an error with respect to the encoded user data has occurred; and

a decoding circuit which decodes the encoded data, which

has been checked by the error checking circuit, to the original user data.

14. A data storage device according to claim 13, wherein said error checking circuit includes an error correcting circuit which corrects errors if said error checking circuit detects any errors with respect to the encoded data as a result of the check.

15. A data storage device according to claim 14, wherein the predetermined record code is a run length limited code for restricting a continuation of a predetermined first value in a series of data, and said converting circuit converts the original error correcting code data into the encoded error correcting code data so that conversion is effected in accordance with the restriction of the run length limited code.

16. A data storage device according to claim 14, further comprising:

a PRML (Partial Response Maximum Likelihood) processing circuit which performs decoding by a PRML using a PR (Partial Response) class 4; and

a pre-coding circuit which pre-codes the encoded data and the encoded error correcting code data so that the encoded error correcting code data is adapted to the record code.

17. An apparatus for reproducing original user data from a medium utilizing a signal read from said medium which is indicative of information including encoded user data of a predetermined record code representing the original user data and an encoded error correcting code which is converted in accordance with restriction of the predetermined record code from an original error correcting code which corrects an error of the encoded user data, said information being written on said medium, comprising:

a read head which obtains a signal indicative of the information written on said medium from said medium;

a reproducing circuit which reproduces the encoded user data and the encoded error correcting code data from the signal read from said medium by said read head;

an inverse converting circuit which inversely converts the encoded error correcting code data read by the reproducing circuit into the original error correcting code data;

an error correcting circuit which corrects an error with respect to the encoded user data reproduced by said reproducing circuit based on the original error correcting code data; and

a decoding circuit which decodes the encoded user data which have been corrected by the error correcting circuit to the original user data.

18. An apparatus according to claim 17, wherein the predetermined record code is a run length limited code for

restricting a continuation of a predetermined first value in a series of user code data.

19. An apparatus for reproducing user data from a recording medium, comprising:

a read head;

a reproducing circuit block which reproduces encoded user data and encoded error correcting code data from a signal read from said recording medium by said read head, said encoded user data being data obtained by converting the user data in accordance with a restriction of a predetermined record code, and said encoded error correcting code data being data obtained by converting an original error correcting code data generated from the original data in accordance with the restriction of the predetermined record code;

an inverse converting circuit block which inversely converts the encoded error correcting code data read by the reproducing circuit into the original error correcting code data;

an error checking circuit block which checks the encoded user data utilizing the original error correcting code data whether or not an error with respect to the encoded user data has occurred; and

a decoding circuit block which decodes the encoded user data, which has been checked by the error checking circuit block, to the original user data.

20. An apparatus according to claim 19, wherein said error checking circuit block includes an error correcting circuit which corrects errors if said error checking circuit block detects any errors with respect to the encoded user data as a result of the check.

21. An apparatus according to claim 20, wherein said predetermined record code is a run length limited code for restricting a continuation of a predetermined first value in a series of the user data.